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*Published in:*
Health & Place

*DOI:*
10.1016/j.healthplace.2017.05.007

*Publication date:*
2017

*Document version*
Publisher's PDF, also known as Version of record



*Citation for published version (APA):*
Stigsdotter, U. K., Corazon, S. S., Sidenius, U., Kristiansen, J., & Grahn, P. (2017). It is not all bad for the grey city - A crossover study on physiological and psychological restoration in a forest and an urban environment. *Health & Place*, *46*, 145-154. https://doi.org/10.1016/j.healthplace.2017.05.007

Health & Place 46 (2017) 145–154

Contents lists available at ScienceDirect

Health & Place

journal homepage: www.elsevier.com/locate/healthplace

# It is not all bad for the grey city – A crossover study on physiological and psychological restoration in a forest and an urban environment☆

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ARTICLE INFO

*Keywords:*
Health promotion
Urbanization
Urban planning
Healthy living environments
Stress restoration
Restorative environments

ABSTRACT

Today, urbanization presents a challenge to urban planning with regard to creating healthy living environments. The aim of this research is to gain further knowledge of the restorativeness of a best case urban and natural environment: that is a historic down town urban environment and forest environment located in an arboretum. The study has a cross-over design where 51 (N) female university students are exposed to the two environments through both seated viewing and walking. A mixed method approach is used with both physiological measurements of blood pressure (BP) and heart rate variability (HRV) and psychological measurements of mood change and perceived restorativeness. The HRV results show no significant differences between the two environments, and both environments are found to be more physiologically restorative than being at the office or on the minibus. The results of the psychological measures indicate that the forest walk has a positive effect on mood, while the walk in the urban environment has no effect. The forest environment is also rated more highly with regard to perceived restorativeness than the urban environment. The results support the current research that shows natural environments as more restorative than urban environments. The study also adds to the ongoing debate on healthy urban planning by indicating that architectural and historical qualities may be associated with the physiological well-being of citizens.

## 1. Introduction

One can say that the urban environment has become our new habitat with more than half of the world's population living in urban areas for the first time in human history (http://www.who.int). Urbanization is predicted to continue, and in 2050 it is expected that 70% of the world's population will be living in cities (*ibid.*). The rapid urbanization has resulted in many challenges to urban planning and design with regard to creating healthy everyday living environments. According to the United Nations (UN) program 'Working towards a better urban future': "Many cities still underestimate the importance of a city's look and feel, public spaces, and public infrastructure, failing to fully comprehend the correlation with quality of life, social development, and other key components of human well-being" (http://unhabitat.org). Urbanization may further be connected to ill health in the form of the rise in non-communicable diseases such as obesity, diabetes II, osteoporosis and stress-related illnesses such as heart disease, depression and mental fatigue (World Health Organisation, 2010).

Healthy urban planning often refers to research on the positive outcomes of nature and human health relations, and there is growing evidence of and political interest in promoting natural environments for public health as part of creating sustainable cities (European Commission, 2014; World Health Organization, 2016). An increasing number of studies demonstrate that natural environments have positive impacts on human health with regard to encouraging physical activity (Lovell, 2016), facilitating social cohesion (Maas et al., 2009), and by promoting psychological (Bratman et al., 2015) and physiological restoration (Hartig et al., 2003; Park et al., 2010). The term restoration stems from the field of environmental psychology and, according to Joye and van den Berg, refers to " the experience of a psychological and/or physiological recovery process that is triggered by particular environments and environmental configurations" (Joye and van den Berg, 2013, p. 58). A restorative environment should offer the visitor four specific components; fascination (to draw attention without cognitive effort), extent (immersion in a coherent environment), being away (from daily hassles and obligations) and compatibility (between the individual's inclinations and the characteristics of the environment) (Kaplan and Kaplan, 1989).

☆ This project was funded by Realdania, the Danish Outdoor Council, the Obel Family Foundation and G.B. Hartmann's Family Foundation.
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http://dx.doi.org/10.1016/j.healthplace.2017.05.007
Received 9 October 2016; Received in revised form 7 May 2017; Accepted 9 May 2017

When it comes to environmental preferences with regard to restoration, natural environments are preferred over built environments in a substantial number of studies (Hartig and Staats, 2006; Joye and van den Berg, 2013; Van den Berg et al., 2003).

The research specifically focusing on forest environments for stress restoration is a relatively new, but a growing area within the research field of restorative natural environments (Meyer and Bürger-Arndt, 2014; Nilsson et al., 2011). At present, Asian, especially Japanese and Korean studies dominate the field of research; more recently in collaboration with Finnish researchers (e.g. Lee et al., 2014; Li et al., 2011; Park et al., 2010, 2011; Song et al. 2013; Takayama et al., 2014; Tsunetsugu et al., 2007). The Japanese and Korean studies operate with the term "forest bathing", which refers to the act of taking in the forest atmosphere (*ibid.*), and they have continued the tradition of studying nature/forests versus built environments, which is a common approach in the research area of restorative environments (Joye and van den Berg, 2013; Staats et al., 2016). The Japanese and Korean studies repeatedly present positive physiological and psychological effects derived from exposure to the forest environments measured by a decrease in blood pressure and cortisol levels, enhancement of parasympathetic nervous activity and elicitation of positive mood change, while negative effects are found to result from exposure to urban environments (e.g. Lee et al., 2014; Li et al., 2011; Park et al., 2010, 2011; Song et al., 2013; Takayama et al., 2014; Tsunetsugu et al., 2007).

However, are all restorative environments necessarily natural environments? The origin of restorative environments stems from Stephen and Rachel Kaplan's research on attention restoration which focuses on natural environments for restoration (Kaplan and Kaplan, 1989). Even though Kaplan et al. (1993) discussed the possibility of other types of environments possessing restorative qualities (e.g. museums), research within restorative environments has in general continued to focus on natural environments for restoration (Joye and van den Berg, 2013). Though a few existing studies focus on non-natural environments for restoration such as historic urban environments (Fornara and Troffa, 2009), monasteries (Ouellette et al., 2005), art galleries (Clow and Fredhoi, 2006) and shopping malls & cafés (Staats et al., 2016). Based on the study by Fornara and Troffa (2009), which found that a historical setting within an urban environment was perceived as restorative as an urban park, one may assume that urban environments with architectonic qualities (like historical and cultural attributes as well as aesthetic values) can also be experienced positively and elicit restorative experiences. This assumption is further supported by the results of a recent study by Staats et al. (2016) in which the authors compare the restorative experience in different urban environments. They found that walking along a busy road was rated low with regard to restoration, whereas being in a mall was rated neutral and sitting in a café received positive ratings with regard to restoration. A study by Herzog et al. (2003) tested the perceived restorativeness of a number of urban and natural environments, and the results also support the notion of the urban environment as potentially restorative. In the study, some of the chosen urban environments exceeded the restorative rating of some of the natural environments, indicating that the choice of setting within the urban and natural environment plays an important role in the experience of restorativeness.

In the previously mentioned Asian crossover studies, serene natural forest environments are compared to urban environments located in urbanized zones, often along major traffic roads or around the main train station. Since the study by Staats et al. (2016) provides evidence that busy urban streets are the least preferred urban areas for restoration, one could argue that the urban environments in the Asian studies are poor representations of a potentially restorative urban environment.

The present study was inspired by the research design used in many of the Asian studies e.g. Park et al. (2010, 2011), Takayama et al. (2014), Tsunetsugu et al. (2007), where the participants both walked in and viewed urban and forest environments. It employed the same measurement as the Japanese study by Park et al. (2010), with measures of heart rate variability (HRV), blood pressure (BP) and mood changes. The study by Park et al. (2010) also employed cortisol measurements, which were not included in the present study, whereas it investigated the participants' perceived restoration, which was not included in the study by Park et al. (2010).

The present research design differed from the study by Park et al. (2010) by using what was expected to be a good case of a forest environment and an urban environment. The forest environment was specially designed according to research on nature experiences, the so-called perceived sensory dimensions (PSDs) (Grahn and Stigsdotter, 2010), while the urban environment was located in the historic part of the capital Copenhagen and comprised pedestrian areas with architectonical, cultural and historic qualities, although almost no vegetation.

The aim of the research was to gain further knowledge of the restorativeness of the two environments and their possible impact on physiological and psychological processes. Further, the aim was to extend the research perspective on the choice of urban environment for crossover studies in this field of research.

The research questions guiding the research were:

- Does exposure to a forest and an urban environment through seated rest and walking have an impact on physiological and psychological processes measured in HRV, BP and mood change?
- How are the two environments perceived with regard to restorativeness measured in the four components 'being away', 'fascination', 'compatibility' and 'extent'?

## 2. Method

### 2.1. Participants

We recruited 51 (N) female university students in Copenhagen Denmark to participate in the study (age 20–36). The students were recruited through posters and notice boards, and came from a broad variety of studies within the University of Copenhagen. Exclusion criteria were expert knowledge within the research field e.g. studying landscape architecture or related subjects, drug abuse or taking medications related to cardiovascular function, and/or mental illness. The study was performed under the regulations of the Danish Committee on Health Research Ethics. The participants were fully informed about the aims and procedures of the study, and their written consent was obtained before initiating the research. The participants in the Asian studies were primarily male university students. It was discussed if this study also should recruit male students to have a closer match with the Asian studies. But since cultural difference between Asian and Danish students most likely in itself would make comparison difficult it was decided instead to only recruit female students to balance the research area with regard to gender. Due to limitations in sample size it was not possible to recruit both male and female students and keep them as separate groups in the analyses.

### 2.2. Experimental procedure

The study had a cross-over design where all participants (N=51) were exposed to the two different environments; the health forest Octovia® and the urban downtown environment (see section: Study environments for a description of the two environments). The participants were divided into groups of 4–5 persons. Each group was

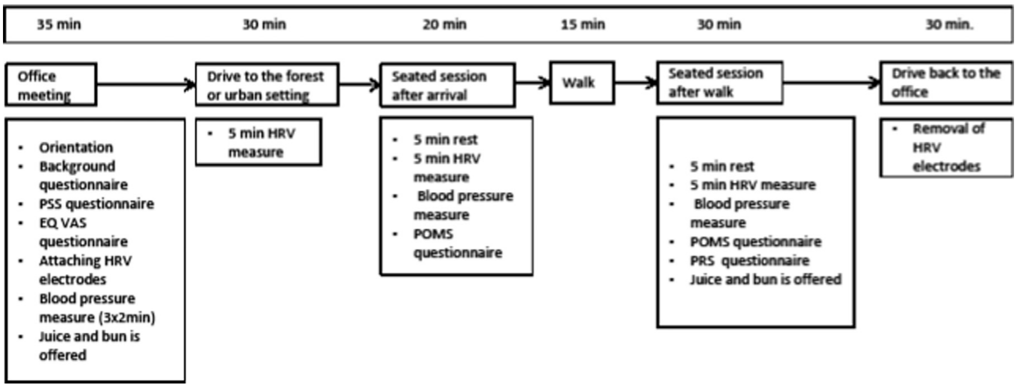


**Fig. 1.** Experimental plan.

exposed to the two environments on different days within 2 weeks. Half of the groups started in the forest environment and the other half in the urban environment. Half of the data collection took place in the autumn of 2014 (n=21 participants) and the other half in the spring of 2015 (n=20 participants), since it was decided not to have data collection during winter, where there is less green vegetation.

The same procedure took place for each environment (see Fig. 1): the groups met at an office at the university facility where they answered the background questionnaire, the general well-being questionnaire (EQ VAS) and the perceived stress scale questionnaire (PSS) individually.

Afterwards, a portable heart rate monitor was attached to measure heart rate variability (HRV). Blood pressure measures were performed three times at two minutes intervals. During the time at the office, the participants were offered a bun and some fruit juice. They were then transported to the test environment by a minibus. Before entering the bus they were told which environment they were going to visit. The drive to both the forest and the urban environment had been planned so that they were of the same duration. The first HRV measurement was made, while the participants were seated in the bus during transport.

Upon arrival at the environment, the participants were seated in comfortable chairs just next to the car at the entrance to the area. Here they had a 5 min rest, followed by the second HRV measurement, completion of the perceived mood change (POMS) questionnaire and then their blood pressure was taken for a second time. The participants then engaged in a fifteen-minute walk through the environment followed by another five-minute seated rest in a new location at the end of the walk. After the rest, the HRV measures were repeated, followed by blood pressure measures.

The session ended with the participants filling out the POMS questionnaire for the second time and the perceived restorativeness scale (PRS) questionnaire. Afterwards, they were offered a bun and some fruit juice again before driving back to the university where the heart rate monitor was removed. The participants were encouraged not to talk and they were not allowed to smoke, drink coffee/tea or use phones during the experiment.

### 2.3. Study environments

#### 2.3.1. The forest environment

The forest environment used in the study is the Danish Health Forest, Octovia®, which is located in an Arboretum, containing the largest collection of trees and shrubs in Denmark (Jensen, 1994). The Health Forest Octovia® has been established in an area measuring 2 ha within the Arboretum (see Fig. 2 for pictures of the health forest). The area was initially chosen due to its diverse vegetation and richness in nature qualities. Specific sensory experiences have further been re-enforced based on the landscape architects Grahn and Stigsdotter's (2010) research on perceived sensory dimensions (PSDs) in natural environments. The PSDs each represent a number of variables related to various nature experiences, which Grahn and Stigsdotter have identified through their research within a representative sample of the Swedish population (*ibid.)* (Grahn and Stigsdotter, 2010; Stigsdotter and Grahn, 2011). In total, Grahn and Stigsdotter have identified eight PSDs, which have been designed as eight rooms with various nature experiences that are linked together by a 750 m trail, creating a circular forest walk, that entails open views over the landscape, secluded areas surrounded by greenery, a lake, deciduous and pine forest (see Appendix A for an overview of the walk). The design process of the health forest has been transparently described and documented (Stigsdotter et al., 2014).

#### 2.3.2. The urban environment

A historic downtown area in the center of Copenhagen was chosen to represent the urban environment due to its architectonical and historical qualities (see Fig. 3). The walk started at Bremerholmen – a narrow street close to the canals of Copenhagen, where cars pass by. It then continued to Sankt Nicolai Square, where the third oldest church in Copenhagen is located. Most of the church burned down in 1795, but it was re-constructed in the original late-gothic style. The walk then passed Amager Square with the Stork Fountain – a local landmark. It continued down a quieter pedestrian side street with colorful 3–4 storey apartment buildings, some of which are built in the traditional Danish timber style, dating back to the 19th century. From here, the walk followed the main pedestrian street, which led through the oldest town square in Copenhagen "Old Square", with the Caritas Fountain from 1610 and the adjoining "New square", which is dominated by the Copenhagen Court House, built in the neoclassic style and dating back to 1805. The walk terminated in front of the City Hall, which was built on the main square between 1892 and 1905 in the national romantic style. The environment contained very little greenery except for an arcade of linden trees on Sankt Nicolai Square (see Appendix B for an overview of the walk).

### 2.4. Measurements

#### 2.4.1. Blood pressure and heart rate variability measurements

Systolic and diastolic blood pressure (BP) was measured with automated blood pressure devices (Omron M6 Comfort). Systolic and diastolic blood pressure indicates how much pressure your blood is

**Fig. 2.** Pictures of the forest walk.

exerting against the artery walls respectively when the heart beats and when it is at rest between beats. Together they can give an indicator or the body's state of arousal or relaxation (Kulkarni et al., 1998). Blood pressure was measured three times during the intervention on the left arm with the participants resting in a seated position (see Fig. 1 for experimental plan). Each measure was taken three times at two-minute intervals (Vinyoles et al., 2010). The participants rested for 5 min before the measurements.

The participants' heart rate variability (HRV) was recorded during the experiment using Actiheart monitors (CamNtech, Cambridge, Ltd., UK). The Actiheart recorder was fixed to two ECG electrodes (White Sensor, Ambu, Ballerup, Denmark) on the participants' upper chest, and the HRV measurements were taken while the participants were seated in order to achieve approximate cardiac regulatory stationarity.

The Actiheart recorder stores interbeat intervals with a resolution of 1 ms. HRV was calculated for 5-min segments. First, the 5-min segment was mathematically filtered to detect and remove ectopic heart beats and artefacts (Kristiansen et al., 2011). Segments with more than 10% ectopic beats or artefacts were rejected and not used in the HRV analysis. Second, the HRV spectral components were estimated by a robust period detection algorithm (Skotte and Kristiansen, 2014).

HRV is a measure of the cardiac control exerted by the central autonomic nervous system (ANS). High frequency power (HFP) is an indicator of parasympatic modulation of cardiac activity, whereas low frequency power (LFP) is an indicator of sympathetic modulation of cardiac activity (Kleiger et al., 2005). The ratio of low-to-high frequency power (LF/HF) reflects the 'sympathovagal balance', i.e., the balance between sympathetic and parasympathetic modulation of the cardiac rhythm (Malliani et al., 1998). Both physical and psychological stress affect HRV. Thus, autonomic cardiac regulation is shifted towards more sympathetic and less parasympathetic activity during stress, which is manifested in an increase in LFP and LF/HF and a decrease in HFP and TP.

#### 2.4.2. Psychological measurements

The psychological measurements included questionnaires regarding the participant's' mood change (profile of mood state questionnaire), the perceived restorative qualities of the environment (perceived restorativeness scale questionnaire), their stress level (perceived stress scale questionnaire) and their health status (EQ VAS).

The profile of mood state (POMS) questionnaire is a self-reporting measure that allows an assessment of fluctuating affective mood states (McNair and Heuchert, 2013). There are two rating options for assessing mood: the past week or right now. In this study the option: Right now was chosen for the assessment, in order to use the questionnaire as a pre-post measure of the walk in the environment. The POMS questionnaire, used in the present study, consisted of 65 adjectives rated on a six-point scale, ranging from "not at all" to "very much". The mood states are measured within six factors: Tension-Anxiety (T), Depression-Dejection (D), Anger-Hostility (A), Vigor-Activity (V), Fatigue-Inertia (F), and Confusion-Bewilderment (C). The analytically derived questionnaire is validated through several independent factor analytical studies (*ibid*).

The participants rated their restorative experience of the environments on the perceived restorativeness scale (PRS) questionnaire (for validation, see Hartig et al. (1997)). The PRS questionnaire comprises 24 questions and measures the subject's experience of the restorative qualities of the environment within the 4 components: being away, extent, fascination and compatibility. The four components are derived from Steven and Rachel Kaplan's theory on what constitutes a restorative environment (Kaplan and Kaplan, 1989).

The participants' stress level was measured by the perceived stress scale (PSS) questionnaire, which consists of 10 items rated on a five-point Likert scale. It measures the participants' feelings and thoughts related to stress over the past month. The total PSS scores range from 0 to 50 with higher scores indicating greater perceived stress. The questionnaire is widely used and has been validated through research (Cohen et al., 1983; Wartig et al., 2013). The participants' health level was measured by having them fill out the EQ VAS, which records the respondent's self-rated health on a vertical, visual analogue scale where the endpoints are labeled "Best imaginable health state" (assigned the value=100) and "Worst imaginable health state" (assigned the value=0) (For validation, see: The EuroQol Group's International Task Force on Self- Reported Health, 2004).

The PSS questionnaire and the EQ VAS were used to draw a profile of the participants' present health state.

## 3. Results

### 3.1. Background measures

The results from the EQ VAS questionnaire showed an average state of self-reported health, with a mean score of 3.59 points below norm values from a Finnish representative sample of women aged 18–39 years (The EuroQol Group's International Task Force on Self-Reported Health, 2004) (see Table 1). The results from the PSS questionnaire showed somewhat above average scores for self-rated stress levels, compared to norm values from a UK sample (Wartig et al., 2013) (see Table 1). In the UK sample, the short 4-item scale (question 2, 3, 5 and 10 of the PSS 10-item scale) has been used to calculate the norm

**Fig. 3.** Pictures from the urban walk.

**Table 1**
General health and stress level scores measured by EQ VAS and PSS.

| | N | Mean score | Normative scores |
|---|---|---|---|
| Self-rated health (EQ VAS) | 46[a] | 83.56 | 87,15 |
| Perceived stress (PSS) | 51 | 8.44[b] | 6,36[b] |

[a] *Note.* Three participants did not answer the EQ VAS questionnaire and two extreme cases were excluded in order to obtain a more homogeneous measure of self-rated health for the group, exclusion criteria score < 40.
[b] *Note.* The mean score is based on the 4 item PSS scale.

**Table 2**
Blood pressure in the forest and urban environment. The difference between forest and urban environments was tested in a paired *t*-test: * P < 0.05.

| Blood pressure variable | | Condition seated | | | | | |
|---|---|---|---|---|---|---|---|
| | | Office | | Before walking | | After walking | |
| | Environments | Mean | SD | Mean | SD | Mean | SD |
| Systolic blood pressure (SBP) | Urban | 106,8 | 9,10 | 105,4 | 8,94 | 104,8 | 8,67 |
| | Forest | 104,7 | 8,16 | 102,8 | 9,34 | 101,7 | 9,67 |
| | *Difference* | −1,8 | 8,90 | −2,2 | 10,50 | −3,1* | 9,57 |
| Diastolic blood pressure (DBP) | Urban | 74,1 | 8,30 | 72,4 | 8,21 | 72,5 | 8,48 |
| | Forest | 72,6 | 7,93 | 69,6 | 7,76 | 70,2 | 7,98 |
| | *Difference* | −1,4 | 9,94 | −2,4 | 9,35 | −2,4 | 9,32 |

scores. In order to compare the present research with the UK sample, the short item scale has, therefore, also been used to calculate the participants' average score on self-rated stress.

### 3.2. Outcome measures

#### 3.2.1. Blood pressure

Table 2 shows the results from the blood pressure measurements, comparing the forest and urban measurements in three conditions: office, before walking in the environment, after walking in the environment. The results shows significantly lower (3.1 mmHg) systolic blood pressure (SBP) after walking in the forest environment compared to after walking in the urban environment (P < 0.05).

Both the systolic and diastolic blood pressure were significantly higher in the office compared to each of the two environments, both before and after walking (P≤0.05) (paired *t*-test). There was no significant difference in systolic and diastolic BP before and after the walk in either of the environment.

In Table 2, the SBP measured after the walk is significantly lower in the forest than in the urban environment. However, it is also lower in the office, although the difference is not statistically significant. Hence, we looked at the change in blood pressure from the office to before and after the walk, and compared the forest and urban results in a paired *t*-test. In this way, the effect of the environment is adjusted for the individual BP level before exposure to the environment. The test showed that with this adjustment, the change in SBP measured in the forest is not significantly different from those measured in the urban environment.

### 3.3. Heart rate variability

A complete set of Actiheart recordings (forest and urban) was obtained from 43 participants. Some HRV measurements were rejected because of more than 10% artefacts and ectopic beats, which reduced the number of valid HRV measurements to 39 before and 34 after walking in the environment.

**Table 3**
Estimates of HRV in the bus and both environments (before and after walking) mean (SE).

| | Bus | Before walk | After walk |
|---|---|---|---|
| ln(TP) | 7,43 (0,07) | 7,56 (0,11) | 7,64 (0,11)* |
| ln(LFP) | 6,41 (0,09) | 6,21 (0,13) | 6,20 (0,12) |
| ln(HFP) | 5,68 (0,11) | 6,25 (0,15)*** | 6,36 (0,13)*** |
| ln(LF/HF) | 0,72 (0,11) | −0,04 (0,12)*** | −0,14 (0,09)*** |

*Note I.* Statistically different from the bus ride measure as baseline: ***P≤0.001; ** P≤0.01; * P≤0.05.
*Note II.* The table is based on the mean value of the HRV measures for the forest and urban environment, which has been summed and averaged. It was decided to use this method since there was no statistical difference between the HRV measures in the two environments.

There was no statistically significant difference between any of the HRV variables when comparing HRV in the forest with HRV in the urban environment. This was true when comparing measurements in the bus, before walking in the environment, and after having walked in the environment (data not shown).

When comparing the HRV measurements from the bus ride to the mean values of HRV before and after walking in either environment, there is a significant effect on several HRV measures towards larger parasympatic nervous activity (see Table 3). This is shown by a significant rise in high frequency HRV (ln(HFP)), (P≤0.001), between the bus and before and after walking in the environments. Also a significant fall in low to high frequency HRV (ln(LF/HF)) is detected between the bus to before and after the walks (P < 0.001). There was no significant difference in HRV between before and after the walks in the environments.

### 3.4. Profile of mood states

The results from the perceived mood states questionnaire were analyzed by performance means with regard to mean value, confidence interval (Confidence limits 95% low/high), p-value (Wilcoxon signed rank test) and effect size (Hedges'g) (see Table 4).

The reduction in mood disturbance was only statistically significant for the forest walk, where there was a significant fall in the variable "Fatigue-Inertia" (p < 0.05) and total mood disturbance (p < 0.05). In relation to effect size (Hedges'g), the POMS variables "Tension-Aggression", "Fatigue-Inertia" and "Confusion-Bewilderment" were substantially reduced by the forest walk.

The starting values for the two environments showed that several of the POMS variables in the urban environment had higher values compared to the forest environment (data not shown). Therefore, significance (Wilcoxon signed rank test) and effect size (Hedges'g) were calculated for the difference in starting values. The results showed that the following four POMS variables had significantly higher starting values in the urban environment: Tension-Aggression (p < 0.0001, ES Hedges'g=0.78), Depression-Dejection (p < 0.05, ES Hedges'g=0.39), Anger-Hostility (p < 0.05, ES Hedges'g=0.26), Confusion-Bewilderment (p < 0.01 W, ES Hedges'g=0.39). Also total mood disturbance was significantly higher at the outset in the urban environment (p < 0.01, ES Hedges'g=0.35). This difference in starting values could be caused by the participants already experiencing a mood improvement from sitting in the forest environment compared to sitting in the urban environment.

In Table 5 an overview of the results of the different physiological and physiological outcome measures is provided.

### 3.5. Perceived restorativeness scale

There was a significant difference between the forest and urban environment in the average scores of PRS (Fig. 4), where the forest environment was rated more highly than the urban environment in all the four components: Being away, fascination, extent and compat-

**Table 4**
Changes in POMS variables before and after walking in the forest and urban environment (N=47).

| Variable POMS | Variable environment | Mean | CL low 95% | CL high 95% | Standard deviation | P (Wilcoxon signed rank) | ES (H)g |
|---|---|---|---|---|---|---|---|
| | Urban B | 6.57 | 4.93 | 8.22 | 5.60 | | |
| Tension-Anxiety | Urban A | 6.30 | 4.99 | 7.60 | 4.44 | ns | 0.05 |
| | Forest B | 2.95 | 1.94 | 3.97 | 3.46 | | |
| | Forest A | 2.26 | 1.47 | 3.04 | 2.67 | ns | 0.23* |
| | Urban B | 4.57 | 2.63 | 6.52 | 6.64 | | |
| Depression-Dejection | Urban A | 3.60 | 2.19 | 5.00 | 4.78 | $P < 0.10$ | 0.17 |
| | Forest B | 3.28 | 1.38 | 5.17 | 6.44 | | |
| | Forest A | 2.94 | 0.97 | 4.90 | 6.68 | ns | 0.05 |
| | Urban B | 3.26 | 1.95 | 4.56 | 4.45 | | |
| Anger-Hostility | Urban A | 3.87 | 2.25 | 5.39 | 5.18 | ns | 0.13 |
| | Forest B | 2.15 | 0.94 | 3.36 | 4.12 | | |
| | Forest A | 1.91 | 1.05 | 2.78 | 2.93 | ns | 0.07 |
| | Urban B | 6.55 | 4.70 | 8.41 | 6.32 | | |
| Fatigue-Inertia | Urban A | 6.40 | 4.75 | 8.06 | 5.64 | ns | 0.03 |
| | Forest B | 6.70 | 5.10 | 8.31 | 5.46 | | |
| | Forest A | 5.49 | 3.84 | 7.14 | 5.61 | $p < 0.05$ | 0.22* |
| | Urban B | 7.17 | 5.80 | 8.56 | 4.65 | | |
| Confusion-Bewilderment | Urban A | 6.62 | 5.49 | 7.75 | 3.85 | ns | 0.13 |
| | Forest B | 5.60 | 4.64 | 6.55 | 3.26 | | |
| | Forest A | 4.77 | 3.95 | 5.58 | 2.78 | $P < 0.10$ | 0.27* |
| | Urban B | 12.57 | 10.65 | 14.50 | 6.55 | | |
| Vigor-Activity | Urban A | 11.40 | 9.49 | 13.31 | 6.51 | $P < 0.10$ | 0.18 |
| | Forest B | 13.36 | 11.56 | 15.16 | 6.13 | | |
| | Forest A | 13.85 | 11.84 | 15.86 | 6.84 | ns | 0.08 |
| | Urban B | 15.55 | 8.34 | 22.76 | 24.56 | | |
| Total POMS | Urban A | 15.38 | 8.88 | 21.89 | 22.15 | ns | 0.01 |
| | Forest B | 7.32 | 0.68 | 13.96 | 22.63 | | |
| | Forest A | 3.51 | −2.84 | 9.86 | 21.64 | $P < 0.05$ | 0.17 |

*Note I*. B=before walk, A=after walk. Eg. Urban B is the POMS measures from the seated session before the walk and Urban A is the POMS measures from the seated session after the walk, and likewise with Forest B and Forest A.
*Note II*. CL=confidence limits, ES (Hg)=Effect size, Hedges' g. Effect magnitude $*ES > 0.2$;$**ES > 0.5$; $***ESS > 0.8$.

**Table 5**
Overview of statistically significant results in outcome measures after walking in the two environments from baseline measures in office (BP), bus(HRV) and before walk (POMS).

| | | Environment – after walk | |
|---|---|---|---|
| **Measures** | | Forest | Urban |
| HRV: | Parasympatic activity – Ln(HPF) | ↑ | ↑ |
| | Sympatic activity – Ln(LF/HF) | ↓ | ↓ |
| BP: | Systolic blood pressure | ↓ | ↓ |
| | Diastolic blood pressure | ↓ | ↓ |
| POMS: | Fatigue/Inertia | ↓ | |
| | Total mood disturbance | ↓ | |

*Note*. The arrows indicate whether there is a statistically significant fall or rise in the measure.

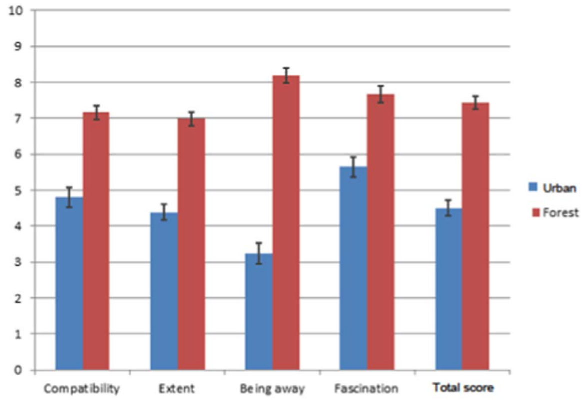


**Fig. 4.** The mean values of the PRS scores in the urban and forest environment with standard error of means indicated (N=46). *Note I*. Significance: $p < 0.001$ to-tailed for all four components and total score.

ibility. The largest difference between the two environments was found in Being Away (Forest Mdn=8.4, Urban Mdn=2.9). The total PRS score for the urban environment was 4.5 (SD=1.40) whereas it was 7.4 (SD=1.15) for the forest environment.

In order to gain knowledge on how the scores in the PRS were related to the outcomes in POMS a Spearman correlations analysis was performed (Table 6). First the difference between the scores in PRS between the forest and urban environment were calculated and then correlated to the difference in the POMS scores after the walk in the two environments. In Table 6 the correlation coefficients and significance levels of the correlations are presented.

As shown in Table 4 the only significant changes in POMS after the walk were for Fatigue and total POMS in the forest environment. When we investigated whether these two dimensions correlated with the results of the PRS-scale, we found significant correlation between fatigue and fascination (p˂0.01); and between fatigue and compatibility ($p < 0.05$). Between total POMS and PRS all the four dimensions showed significant correlations ($p < 0.0001$ Fascination, $p < 0.001$ Compatibility, $p < 0.01$ Being away and $p < 0.05$ Extent).

## 4. Discussion

### 4.1. The physiological results

The exposure to the forest or the urban environment did not show any significant difference in heart rate variability (HRV) and only a slight difference in blood pressure with a larger fall in systolic blood pressure in the forest environment, which disappeared when starting values were adjusted for. Therefore, we must conclude that the physiological impact of the environments on the participants did not differ before or after the walk. These findings contradict previous studies that compare urban environments with natural environments, where a greater decline was found in physiological measures of blood pressure, heart rate or HRV when exposed to natural environments

**Table 6**
The correlation between the differences in perceived restorativeness (PRS) of the environments and change in mood (POMS) after the walk. (N=43).

| PRS | POMS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Tension | Depression | Anger | Fatigue | Confusion | Vigor | POMS |
| Fascination | Difference | 0.50538 | 0.46032 | 0.03614 | 0.39875 | 0.47771 | −0.52846 | 0.58040 |
| | P-value | 0.0005 | 0.0019 | 0.8180 | 0.0081* | 0.0012 | 0.0003 | < 0.0001* |
| Being away | Difference | 0.45383 | 0.22083 | 0.04737 | 0.13274 | 0.35950 | −0.32786 | 0.41177 |
| | P-value | 0.0022 | 0.1547 | 0.7629 | 0.3961 | 0.0179 | 0.0318 | 0.0061* |
| Compatibility | Difference | 0.35656 | 0.42266 | −0.04000 | 0.36006 | 0.46576 | −0.49705 | 0.52661 |
| | P-value | 0.0189 | 0.0047 | 0.7990 | 0.0177* | 0.0016 | 0.0007 | 0.0003* |
| Extent | Difference | 0.43841 | 0.33594 | 0.01191 | 0.21016 | 0.46576 | −0.21446 | 0.35945 |
| | P-value | 0.0033 | 0.0276 | 0.9396 | 0.1762 | 0.0016 | 0.1673 | 0.0179* |

*Note I.* Spearman Correlation Coefficients Prob > |r| under H0: Rho=0.
*Note II.* The correlation between the PRS and the two dimensions in POMS with significant change after the walk are marked with grey, and the significant differences with *.

compared to urban environments (e.g. Hartig et al., 2003; Lee et al., 2014; Park et al., 2010; Sonntag-Öström et al., 2014; Tsunetsugu et al., 2007; Wang et al., 2016).

These differences in results between the studies could be explained by the choice of urban environment. Whereas the aim of the present study was to choose a 'good case' urban environment, which included historical and architectural values, and streets with little or no traffic (nor greenery), the previously mentioned studies all employed urban environments with mainly modern low and high-rise buildings and medium to high traffic density along the main roads, which are among the least preferred urban environments for restoration according to a study by Staats et al. (2016).

Based on these differences among studies, it would be useful to conduct more crossover studies on the restorative or stress-inducing effect of different locations and activities within the urban environment. For example, did the results from the present study show that the urban environment, where the walk took place, was more physiologically restorative than being in the office or on the minibus, which are common places and activities for people living in the city.

### 4.2. The psychological results

Though the results from the physiological measures did not show any difference between the two environments, it seems that the natural environment chosen for this study has more restorative qualities than the urban environment based on the results from the profile of mood state (POMS) questionnaire and the perceived restorativeness scale. Regarding the POMS results, an improvement in mood was found after the forest walk, but not after the urban walk, but only in "Fatigue-Inertia" and total mood disturbance. Nevertheless, the urban walk did not result in a decline in positive mood, which was the case in previous similar studies that use different measurements of mood (e.g. Bratman et al., 2015; Hartig et al., 2003; Park et al., 2010; 2011; Takayama et al., 2014; Tyrväinen et al., 2014; Wang et al., 2016). As in the studies with physiological measures, the urban environments in these studies were mainly located on main streets with traffic.

However, even though the urban environment in the present study did not evoke negative emotions or resulted in negative physiological reactions, whether it has restorative qualities is questionable since it was rated quite low on the perceived restorativeness scale (mean 4.5) compared to the forest environment (mean: 7.4). Based on a study by Tenngart Ivarsson and Hagerhall (2008), environments that are rated below 5 points are not likely to promote restoration. Nevertheless, the urban environment in this study was still rated much more highly than urban environments in previous similar studies (Sonntag-Öström, 2014, PRS value urban environment: 3.2, p. 349; Tyrväinen et al., 2014, PRS value urban environment: 3.8, p. 7; Wang et al., 2016: PRS value urban environment: 2.0, p. 119). The difference in PRS value for the urban environment between the present and previous studies could be part of the explanation as to why the psychological outcome measures on mood also differ between these studies. The PRS scores may help to explain the positive mood change found in the forest environment after the walk based on the identified correlation between total mood disturbance and PRS. This relation between affective restoration and perceived restorativeness is supported by a study by Van den Berg et al. (2003) on environmental preferences and restoration.

It should be noted that the natural environment in the present study is rated higher in perceived restorativeness than any of the natural environment described in the study by Tenngart Ivarsson and Hagerhall (2008) or the natural environments in previous similar studies (Tyrväinen et al., 2014; Wang et al., 2016). Therefore one must conclude that the chosen forest environment, which is designed to reinforce the 8 perceived sensory dimensions identified in Grahn and Stigsdotters (2010). research, represents a best case natural environment for restoration.

Our findings support the studies by Fornara and Troffa (2009) and Herzog et al. (2003) in that urban environments do not induce stress per se. These findings call for a more nuanced approach when choosing urban environments for crossover studies within restorative environment research, which traditionally compares natural environments to urban environments (Joye and van den Berg, 2013). Still the results indicate that the forest environment is the most restorative of the two environments. These findings are in line with previous studies (Bratman et al., 2015; Hartig et al., 2003; Joye and van den Berg, 2013) that show that green environments are generally more restorative than grey environments. However, the results concerning the urban environment and their difference with previous studies demands future consideration of the health promoting potential of urban environments that have historical and architectural values. This may bring a new perspective to the ongoing debate on how to create healthy cities and may also represent a powerful argument for maintaining and restoring historic city centres.

### 4.3. Limitations of the study

It is always difficult to draw generalizations from specific environments such as those selected for this study: the urban environment in a historic capital and the forest environment located in an Arboretum. However, both can be seen as 'good case' environments where qualities and features can be generalized to other urban or forest environments.

The relatively small number of participants and the fact that only females were involved also presents limitations both when generalizing the findings to a larger community and when comparing the results to the Asian studies, which used male participants, in regard to possible gender difference in the response to green space (Richardson and Mitchell, 2010). In order to balance the research field in regard to gender as well as allow a comparison of the results to the Asian study, ideally, both female and male students should have been recruited. Therefore, the findings should be seen as providing gender-dependent indications that need further research with larger mixed gender samples in order to support the validity of the findings in a more general context.

The study design also imposes limitations on the findings. It would have been helpful to have a baseline measure of POMS, for example, performed in the office before the immersion in the environments in order to gain knowledge of the effect of the initial exposure to the environment by sitting and viewing and not just the effect of the walk. Additionally, it would have provided insight into the participants' initial state of mood before starting the experiment, which may have been affected by, for example, experiences leading up to the experiment.

The PRS questionnaire was only used after the walk when the participants were seated. This also leads to limitations in regard to understanding the perceived restorativeness of the different locations in the environment since the answers to the PRS only reflect the restorativeness of the final location.

The fact that the data collection stretched over two seasons: autumn and spring, may have led to bias in the data since the participants' experiences will naturally vary according to the vegetation present during the two different seasons in the forest environment.

### 4.4. Implications for future research, planners and stakeholders

Based on previous research in the field (Meyer and Bürger-Arndt, 2014; Nilsson et al., 2011) and the results of this study, forest environments can have health promoting effects. Having demonstration facilities, such as the health forest Octovia®, where the eight perceived sensory dimensions have been implemented, means that municipalities and other stakeholders in the area have the opportunity to study 'good case' forest design in a real life natural environments. The findings regarding the urban environment further open up new opportunities for exploring whether specific urban areas may potentially promote health, although further research into the different qualities of the urban environment is, of course, needed.

## 5. Conclusion

The physiological measures showed no difference between the forest and urban environment, and they were both more physiologically restorative than being in the office or on the minibus. Further there is good evidence for the psychologically restorative potential of the forest environment which represents a best case natural environment in comparison with other natural environments in similar studies. The conclusion is more ambiguous with regard to the psychologically restorative potential of the urban environment.

Further research on the restorative potential of different urban settings is needed to gain a clearer picture of the potential for stress restoration in the dense and grey city. The findings contribute to the debate on how to plan healthy cities.

## Funding

This project was funded by Realdania (2100-613), the Danish Outdoor Council (101166), the Obel Family Foundation (20122-19056 E 3) and G.B. Hartmann's Family Foundation.

## Appendix A. The forest walk with the eight rooms in the Health Forest Octovia®

The Danish Health Forest, Octovia® is located in an Arboretum in Northern Sealand in the municipality of Hoersholm. The eight pictures represent each of the eight rooms in the health forest which are based on the 8 perceived sensory dimensions (Grahn and Stigsdotter, 2010).

## Appendix B. The urban walk

An historic downtown area in the center of Copenhagen was chosen to represent the urban environment due to its architectonical and historic qualities. The walk starts at Bremerholmen – a narrow street close to the canals of Copenhagen, where few cars pass by, it passes historical buildings, quiet side streets and the main pedestrian area, and terminates at the City Hall at the main square.

## References


Bratman, G.N., Hamilton, J.P., Daily, G.C., 2015. The impacts of nature experience on human cognitive function and mental health. Landsc. Urban Plan. 138, 41–50.

Clow, A., Fredhoi, C., 2006. Normalization of salivary cortisol levels and self-report stress by a brief lunchtime visit to an art gallery by London city workers. J. Holist. Healthc. 3/2, 29–32.

Cohen, S., Kamarck, T., Mermelstein, R., 1983. A global measure of perceived stress. J. Health Social. Behav. 24, 385–396.

European Commission, 2014. General Union Environment Action Programme to 2020 Living Well, Within the Limits of Our Planet. Publications Office of the European Union, Luxembourg.

EuroQol Group's International Task Force on Self-Reported Health, 2004. Measuring Self-Reported Population Health: An International Perspective based on EQ-5D. EuroQol Group, Helsinki, Finland, (EQ-5D).

Fornara, F., Troffa, R., 2009. Restorative experiences and perceived affective qualities in different built and natural urban places. In: Proceedings of the International IAPS-CSBE & Housing Network.

Grahn, P., Stigsdotter, U.K., 2010. The relation between perceived sensory dimensions of urban green space and stress restoration. Landsc. Urban Plan. 95 (3–4), 264–275.

Hartig, T., Staats, H., 2006. The need for psychological restoration as a determinant of environmental preferences. J. Environ. Psychol. 26, 215–226.

Hartig, T., Evans, G.W., Jamner, L.D., Davis, D.S., Gärling, T., 2003. Tracking restoration in natural and urban field settings. J. Environ. Psychol. 23, 109–123.

Hartig, T., Kaiser, F.G., Bowler, P.A., 1997. Further Development of a Measure of Perceived Environmental Restorativeness. Working Paper No. 5. Uppsala University: Uppsala, Finland.

Herzog, T.R., Maguire, C.P., Nebel, M.B., 2003. Assessing the restorative components of environments. J. Environ. Psychol. 23, 159–170.

Jensen, N., 1994. Guide til Arboretet I Hørsholm. The Royal Veterinary and Agricultural University, Copenhagen, Denmark.

Joye, Y., van den Berg, A.E., 2013. Restorative environments. In: Steg, L., van den Berg, A., de Groot, J.I.M. (Eds.), Environmental Psychology. Blackwell, West Sussex, 57–66.

Kaplan, S., Kaplan, R., 1989. The Experience of Nature: A Psychological Perspective. Cambridge University Press, New York: NY.

Kaplan, S., Bardwell, L.V., Slakter, D.B., 1993. The museum as restorative environment. Environ. Behav. 25/6, 725–742.

Kleiger, R.E., Stein, P.K., Bigger, J.T., 2005. Heart rate variability: measurement and clinical utility. Ann. Noninvasive Electrocardiol. 10 (1), 88–101.

Kristiansen, J., Korshøj, M., Skotte, J.H., Jespersen, T., Søgaard, K., Mortensen, O.S., Holtermann, 2011. Comparison of two systems for long-term heart rate variability monitoring in free- living conditions – a pilot study. Biomed. Eng. 10 (1), 10–27.

Kulkarni, S., O'Farrell, I., Erasi, M., Kochar, M.S., 1998. Stress and hypertension. Wis. Med. J. 11, 34–38.

Lee, Juyoung, Tsunetsugu, Y., Takayama, N., Park, B.J., Li, Qing, Song, C., Komatsu, M., Ikei, H., Tyrväinen, L., Kagawa, T., Miyazaki, Y., 2014. Influence of forest therapy on cardiovascular relaxation in young adults. Evid.-Based Complement. Altern. Med., Retrieved from ⟨https://dx.doi.org/10.1155/2014/834360⟩.

Li, Q., Otsuka, T., Kobayashi, M., Wakayama, Y., Inagaki, H., Katsumata, M., Hirata, Y., Li, Y.L., Hirata, K., Shimizu, T., Suzuki, H., Kawada, T., Kagawa, T., 2011. Acute effects of walking in the forest environments on cardiovascular and metabolic parameters. Eur. J. Appl. Physiol. 111, 2845–2853.

Lovell, R., 2016. Links Between Natural Environments and Physical Activity: Evidence Briefing. Natural England, Exeter.

Maas, J., van Dillen, S., Verheij, R.A., Groenewegen, P.P., 2009. Social contacts as a possible mechanism behind the relation between green space and health. Health Place 15, 586–595.

Malliani, A., Pagani, M., Montano, N., Mela, G.S., 1998. Sympathovagal balance: a reappraisal. Circulation 98, 2640–2644.

McNair, D.M., Heuchert, J.P., 2013. Profile of Mood State. Technical Update. Multi-Health Systems Inc., North Tonawanda, New York.

Meyer, K., Bürger-Arndt, R., 2014. How forests foster human health – present state of research-based knowledge in the field of forests and human health. Int. For. Rev. 16 (4), 421–446.

Nilsson, K., Sangster, M., Gallis, C., Hartig, T., de Vries, S., Seeland, K., Schipperijn, J. (Eds.), 2011. Forests, Trees and Human Health.. Springer, Dordrecht, Holland.

Ouellette, P., Kaplan, R., Kaplan, S., 2005. The monastery as a restorative environment. J. Environ. Psychol. 25, 175–188.
Park, B.J., Tsunetsugu, Y., Kasetamni, T., Kagawa, T., Miyazaki, Y., 2010. The physiological effects of shinrin-yoku (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan. Environ. Health Prev. Med. 15, 18–26.
Park, B.J., Furuya, K., Kasetani, T., Takayama, N., Kagawa, T., Miyazaki, Y., 2011. Relationship between psychological responses and physical environments in forest settings. Landsc. Urban Plan. 102, 24–32.
Richardson, E.A., Mitchell, R., 2010. Gender differences in relationship between urban green space and health in the United Kingdom. Social. Sci. Med. 71 (3), 568–575.
Skotte, J.H., Kristiansen, J., 2014. Heart rate variability analysis using robust period detection. Biomed. Eng. 13 (1), 2–11.
Song, C., Ikei, H., Lee, J., Park, B.J., Kagawa, T., Miyazaki, Y., 2013. Individual differences in the physiological effects of forest therapy based on type A and type b behavior patterns. J. Physiol. Anthropol. 32 (14), Retrieved from ⟨http://jphysiolanthropol.biomedcentral.com/articles/10.1186/1880-6805-32-14⟩.
Sonntag-Öström, E., Nordin, M., Lundell, Y., Dolling, A., Wiklund, U., Karlsson, M., Carlberg, B., Järvholm, L.S., 2014. Restorative effects of visits to urban and forest environments in patients with exhaustion disorder. Urban For. Urban Green. 13, 344–354.
Staats, H., Jahncke, H., Herzog, T.R., Hartig, T., 2016. Urban options for psychological restoration: common strategies in everyday situations. PLoS One. http://dx.doi.org/10.1271/journal.pone.0146213.
Stigsdotter, U.K., Grahn, P., 2011. Stressed individuals' preferences for activities and environmental characteristics in green spaces. Urban For. Urban Plan. 10, 295–304.
Stigsdotter, U.K., Refshauge, A.D., Sidenius, U., Grahn, P., 2014. Concept Manual for the Health Forest Octovia®. University of Copenhagen, Copenhagen, Denmark, (in Danish).
Takayama, N., Korpela, K., Lee, J., Morikawa, T., Tsunetsugu, Y., Park, B.J., Tyrväinen, L., Miyazaki, Y., Kagawa, T., 2014. Emotional, restorative and vitalizing effects of forest and urban environments at four sites in Japan. Int. J. Environ. Res. Public Health 11, 7207–7230.
Tenngart Ivarsson, C., Hagerhall, C.M., 2008. The perceived restorativeness of gardens – assessing the restorativeness of a mixed built and natural scene type. Urban For. Urban Green. 7, 107–118.
Tsunetsugu, Y., Park, B.J., Ishii, H., Hirano, H., Kagawa, T., Miyazaki, Y., 2007. Physiological effects of Shinrin-Yoku (taking in the atmosphere of the forest) in an old-growth broadleaf forest in Yamagata prefecture, Japan. Jpn. Soc. Physiol. Anthropol. 26, 135–142.
Tyrväinen, L., Ojala, A., Korpela, K., Kagawa, T., 2014. The influence of urban green environments on stress relief measures: a field experiment. J. Environ. Psychol., 38, pp. 1–9.
Van den Berg, A.E., Koole, S.L., van der Wulp, S.L., 2003. Environmental preferences for restoration. (How) are they related? J. Environ. Psychol. 23, 125–146.
Vinyoles, E., Vera, M., Cecilia, M., Garcia-Alfaro, M., Fernandez-san-Martin, M., 2010. Blood pressure measurements: the waiting time between readings. J. Hypertens.. http://dx.doi.org/10.1097/01.hjh.0000378944.72286.6b.
Wang, X., Rodiek, S., Wu, C., Chen, Y., Li, Y., 2016. Stress recovery and restorative effects of viewing different urban park scenes in Shanghai, China. Urban For. Urban Green. 15, 112–122.
Wartig, S.L., Forshaw, M.J., South, J., White, A., 2013. New, normative, english-sample data for the short form perceived stress scale (PSS-4). J. Health Psychol. 18/2, 1617–1628.
World Health Organisation, 2010. Global Status Report on Non-Communicable Diseases. Report, WHO, Geneva.
World Health Organization, 2016. Urban Green Spaces and Health – A Review of Evidence. Retrieved from ⟨http://www.euro.who.int/__data/assets/pdf_file/0005/321971/Urban-green-spaces-and-health-review-evidence.pdf?ua=1⟩.